

Unusual ascothoracid nauplii from the Red Sea

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Introduction

The study of larvae is important for elucidating the phylogenetic history of crustacean groups such as the maxillopodans where macroevolutionary events involving progenesis and neoteny may have occurred (Newman, 1983; Boxshall, 1983). It can also reveal homologies between apparently disparate structures such as the attachment disc on the antennule of a cirriped cyprid and the attachment claw on the same limb of an ascothoracid larva (Grygier, 1987*a*). One maxillopodan taxon, the Facetotecta, is still only known from larvae (see Grygier, 1985, 1987*b*). It is therefore, of interest when larvae with clear maxillopodan affinities are discovered which cannot easily be placed in a known group. Grygier (1987*a*) described a 'metanauplius incertae sedis' from the South China Sea which he tentatively identified as a postbrooding ascothoracid, possibly of a laurid (Ascothoracida: Lauridae). During recent plankton studies in the central Red Sea (Böttger, 1987) similar metanauplii were discovered in near surface waters, together with an earlier naupliar stage of what appears to be the same species. These and a similar metanauplius that clearly represents a related but distinct species are described in this paper.

Description

Nauplius type I

Body discoid (Fig. 1A), convex dorsally and concave ventrally; entirely covered with dorsal shield. Surface of shield (Fig. 1B) punctuated with pores arranged in bilaterally symmetrical pattern around lateral margins and in irregular rows either side of dorsal midline. Nauplius eye present. Conspicuous dorsal pore present on swelling about in middle of shield. Margins of shield downturned, provided with extensive ventral band of pores around entire circumference. Posteriorly shield drawn out into paired caudal processes each bearing a small ventral papilla. Papilla with apical pore. Caudal spine originating on ventral surface near posterior margin, 120 µm in length, armed with setules bilaterally. Body dimensions given in Table 1.

Paired frontal filaments simple, setiform but with a blunt tip (Fig. 1A, ff); positioned either side of midline just anterior to bases of antennules; median pore present between filaments.

Antennule (Fig. 1A, atl; Fig. 1C) uniramous, 4-segmented. First segment unarmed; second with 1 naked seta; third with 1 plumose seta; fourth segment showing some signs of subdivision near its apex, armed with 5 plumose and 2 naked setae on and around apex.

Labrum (Fig. 1A, 1a) an elongate muscular lobe extending posteriorly from between bases of antennae; bearing several rows of fine spinules around apex.

Antenna (Fig. 1A, ant; Fig. 2A) biramous, comprising protopod, 3-segmented endopod and 9-segmented exopod. Protopod with 3 endites; proximal endite small, armed with a few spinules; middle endite strongly developed, produced into 2 spiniform processes with 3 slender setae; distal endite strongly developed, produced into 2 divergent spiniform processes, each armed with spinules, 1 naked seta present on anterior surface and a slender plumose seta distally on medial surface. First endopod segment with 3 naked seta, second with 3, third with 4 at tip. First exopod segment unarmed, second to eighth each armed with a long naked seta, ninth segment with 2 setae, that on apex with a swollen base possible representing a tenth segment.

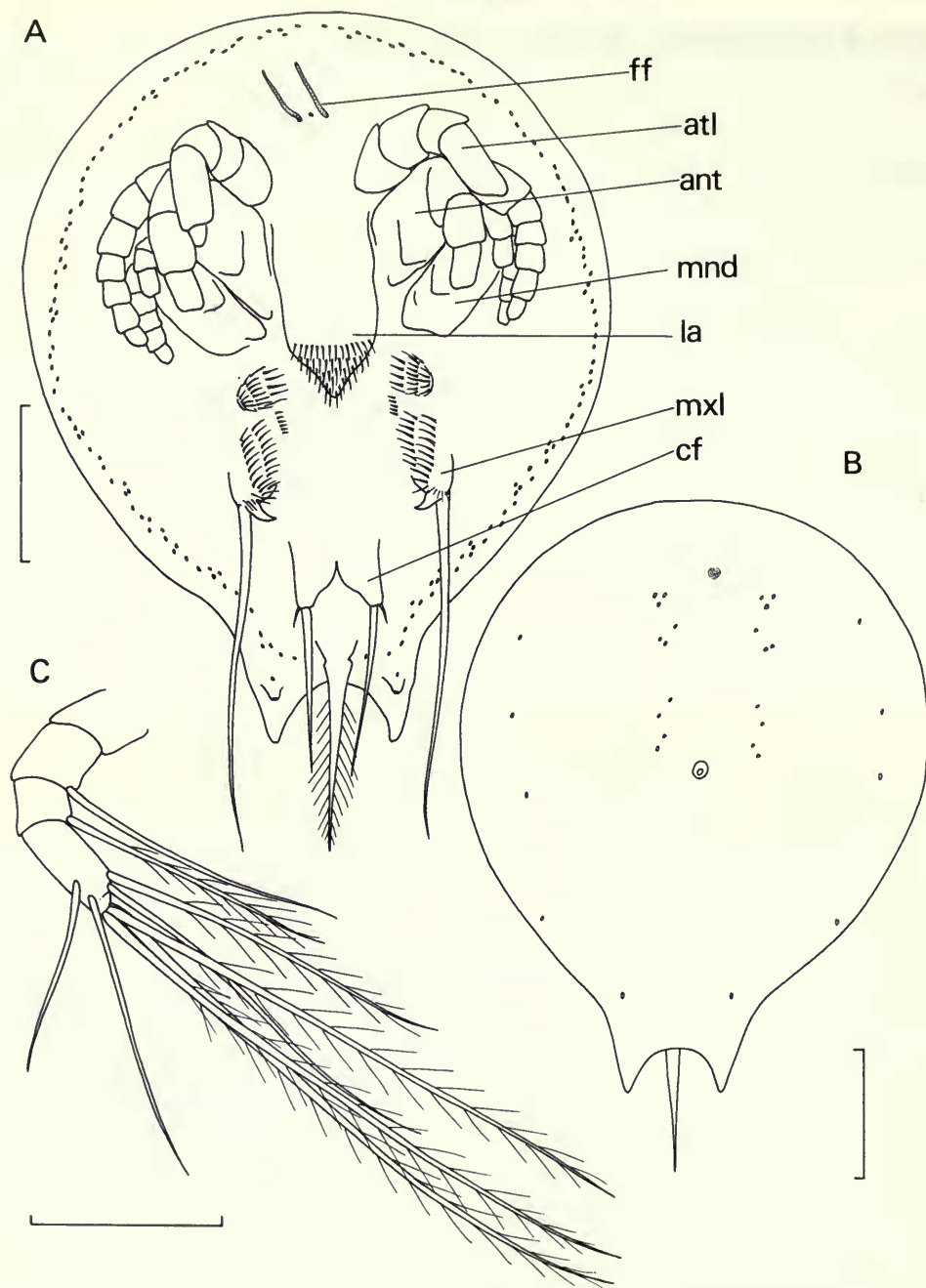


Fig. 1 Red Sea nauplius type I. A, ventral view, showing frontal filaments (ff), antennule (atl), antenna (ant), mandible (mnd), labrum (la), maxillule (mxl) and caudal furca (cf); B, dorsal view; C, antennule, ventral. All scale bars 100 μ m.

Mandible (Fig. 1A, mnd; Fig. 2B) biramous, comprising protopod, 3-segmented endopod and 6-segmented exopod. Protopod with 2 endites; proximal endite armed with a large hirsute seta, a short spine and some spinules; distal endite armed with 4 stout setae, 3 of them plumose, and a row of long spinules. First endopod segment with 2 rows of long spinules, a naked seta and 2 stout setae

bearing long setules, second with 3 naked setae, third with 4 naked setae. First to fifth exopod segments each with a single long seta, that on segment 4 being unusually robust and unilaterally spinulate; sixth segment with 3 naked apical setae.

Paired lobes located on ventral body surface just posterior to mandibles; armed with rows of medially directed spinules. Maxillule (Fig. 1A, mx1) represented by a small lobe bearing a long, posteriorly directed, apical seta, a short incurved spine and rows of medially directed spinules.

Caudal furca (Fig. 1A, cf) comprising paired lobes each bearing an inner naked seta and a short outer spine.

Table 1 Body dimensions and depth distributions of ascothoracid larvae type I in the central Red Sea.

STAGE	DEPTH (m)	DATE (time)	LENGTH (μm)	WIDTH (μm)
Nauplius	0–50	28.10.80(00:20)	443	350
	0–50	05.11.80(15:20)	463	370
	20–40	04.11.80(15:20)	468	344
	mean		458	355
Metanauplius	0–50	27.10.80(11:00)	732	591
	0–50	05.11.80(00:13)	704	561
	0–50	05.11.80(00:13)	728	564
	50–100	27.10.80(11:00)	710	609
	50–100	19.10.80(13:00)	774	589
	50–100	05.11.80(00:13)	743	553
mean			732	578

Metanauplius type I

Body discoid (Fig. 2C) convex dorsally, concave ventrally; entirely covered with dorsal shield. Surface of shield ornamented with fine lamellae anteriorly and posteriorly, and punctuated with numerous pores arranged more or less symmetrically in an irregular row either side of the midline and over entire dorsolateral area. Tripartite nauplius eye well developed. Middorsal pore present but less conspicuous than in early nauplius. Posteriorly shield bearing 3 pairs of sensory setules. Equatorial ring of marginal pores on ventral surface of downturned shield margins present. Caudal processes bearing marked papillae both dorsally and ventrally; ventral papilla with an apical pore. Caudal spine 278 μm long. Body dimensions given in Table 1. Frontal filaments as in early nauplius.

Antennule (Fig. 3B) uniramous, 6-segmented. First segment unarmed; second and third each with 2 plumose setae, fourth with 3 plumose setae and a prominent angled spine passing obliquely across next segment; fifth segment with 4 long plumose setae, sixth with 4 long naked setae. Labrum as in early nauplius.

Antenna (Fig. 4A) biramous, comprising 2-segmented protopod, 3-segmented endopod and 12-segmented exopod. First protopodal segment (coxa) with single well developed endite bearing 2 slender naked setae basally and 2 curved spines apically, one of which is armed with small denticles distally. Second segment (basis) produced into strong endite bearing 2 setulate spines apically, 2 plumose setae present on anterior surface at base of endite. First endopod segment with 3 naked setae and a row of spinules; second with 7 marginal setae and a patch of spinules; third with 4 apical setae. First exopod segment unarmed, second to eleventh each with a long seta, twelfth segment with 1 medial and 1 apical seta, the latter with a swollen base probably representing a thirteenth segment.

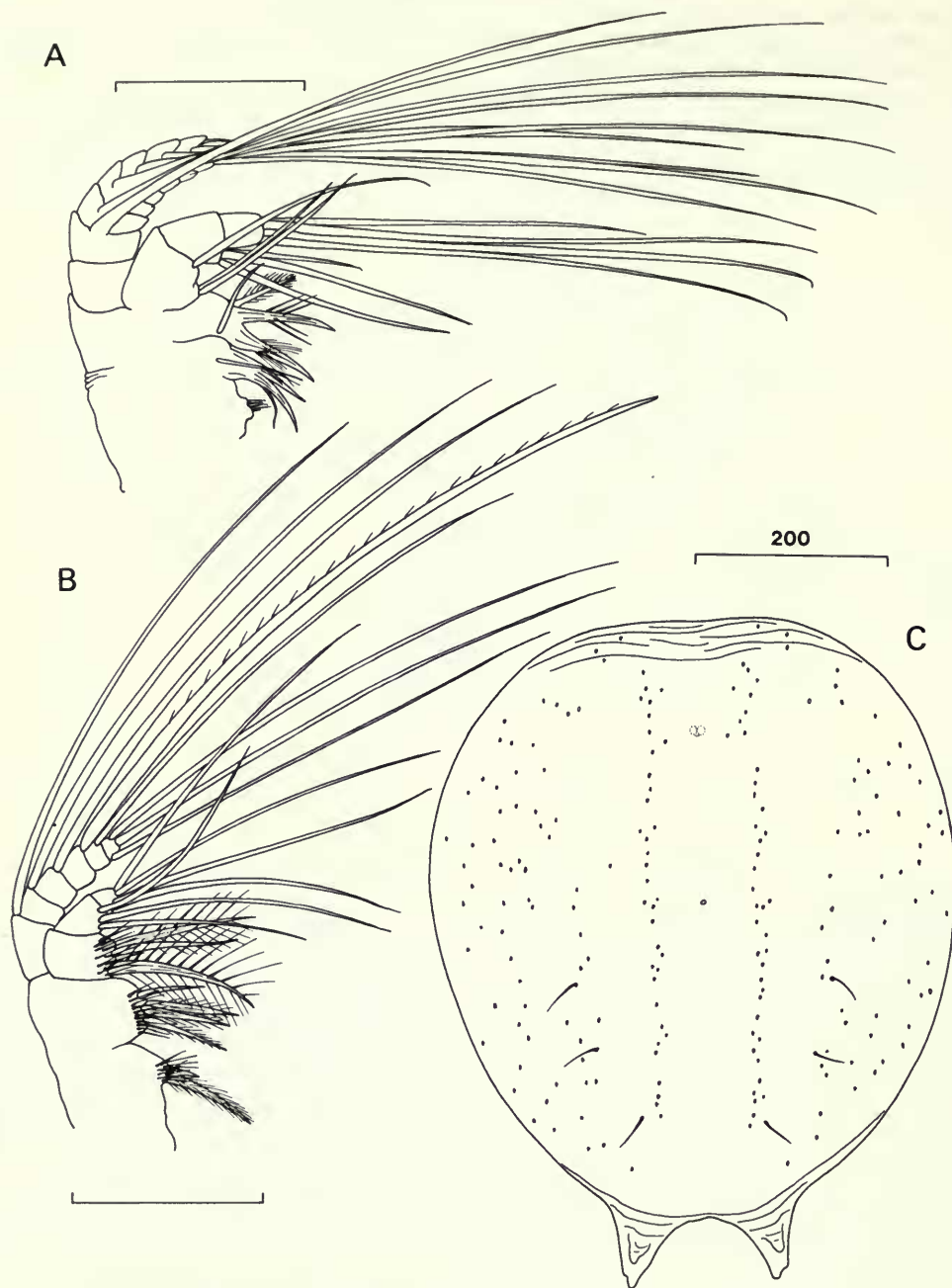


Fig. 2 Red Sea nauplius type I. A, antenna, medial; B, mandible, medial. Red Sea metanauplius type I. C, dorsal view. Scale bars 100 μ m unless otherwise stated.

Mandible (Fig. 4B) biramous, comprising 2-segmented protopod, 3-segmented endopod and 7-segmented exopod. First protopod segment (coxa) armed with a large plumose seta, a short spine and some spinules; second armed with 5 stout setae, 4 of which are plumose, and some spinules. First endopod segment bearing 3 stout spinulate setae, second with 6 naked setae, third with 3

unilaterally plumose and 2 naked setae. First exopod segment unarmed; second to fourth each with a long seta; fifth with a robust, unilaterally spinulate seta; sixth with a plumose seta and seventh with 3 plumose setae.

Maxillule (Fig. 3C) 2-segmented; first segment fused with body surface, armed with rows of

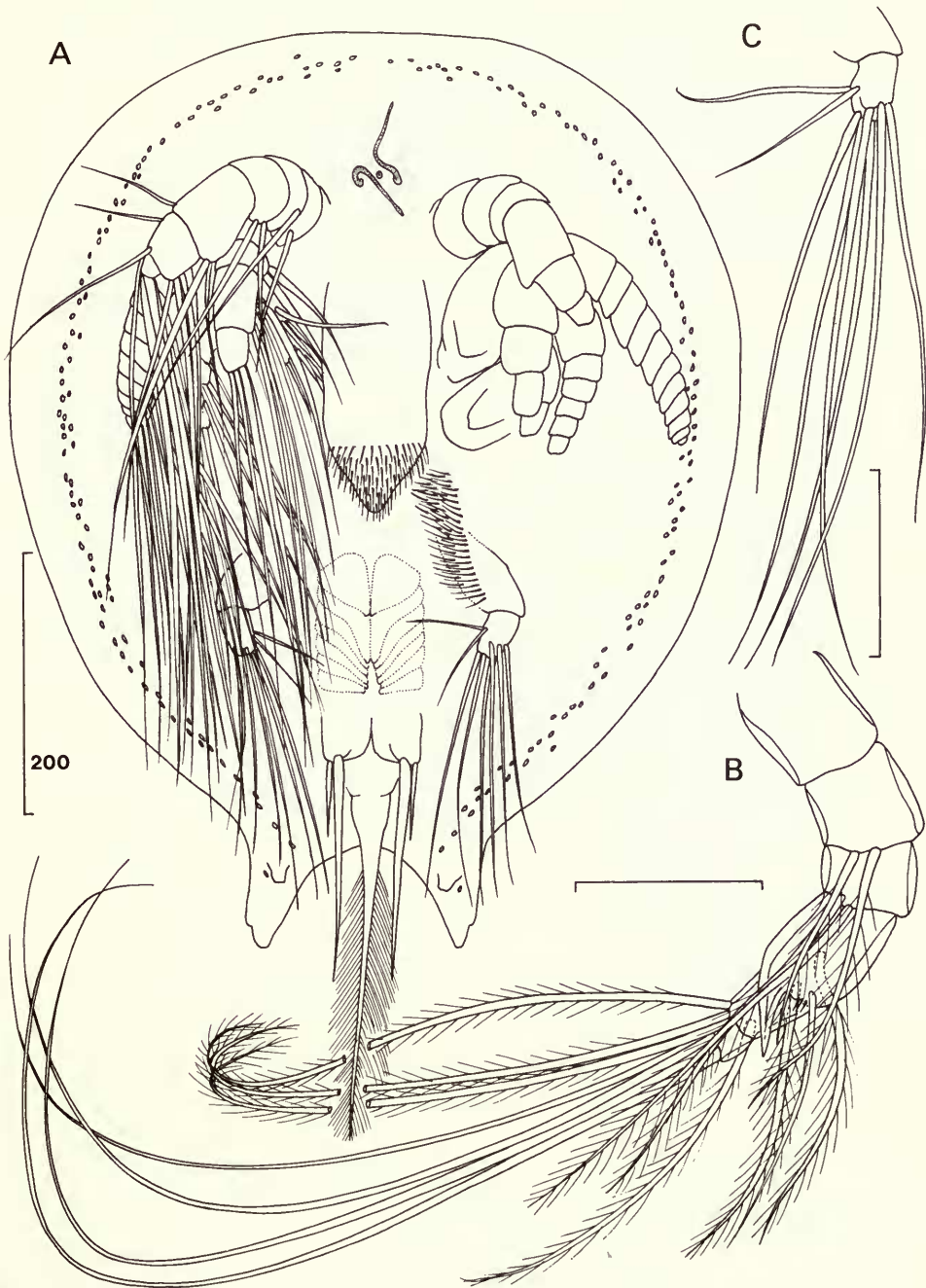


Fig. 3 Red Sea metanauplius type I. A, ventral view, with setae omitted from anterior limbs on left side; B, antennule, medioventral; C, maxillule, ventral. Scale bars 100 μ m unless otherwise stated.

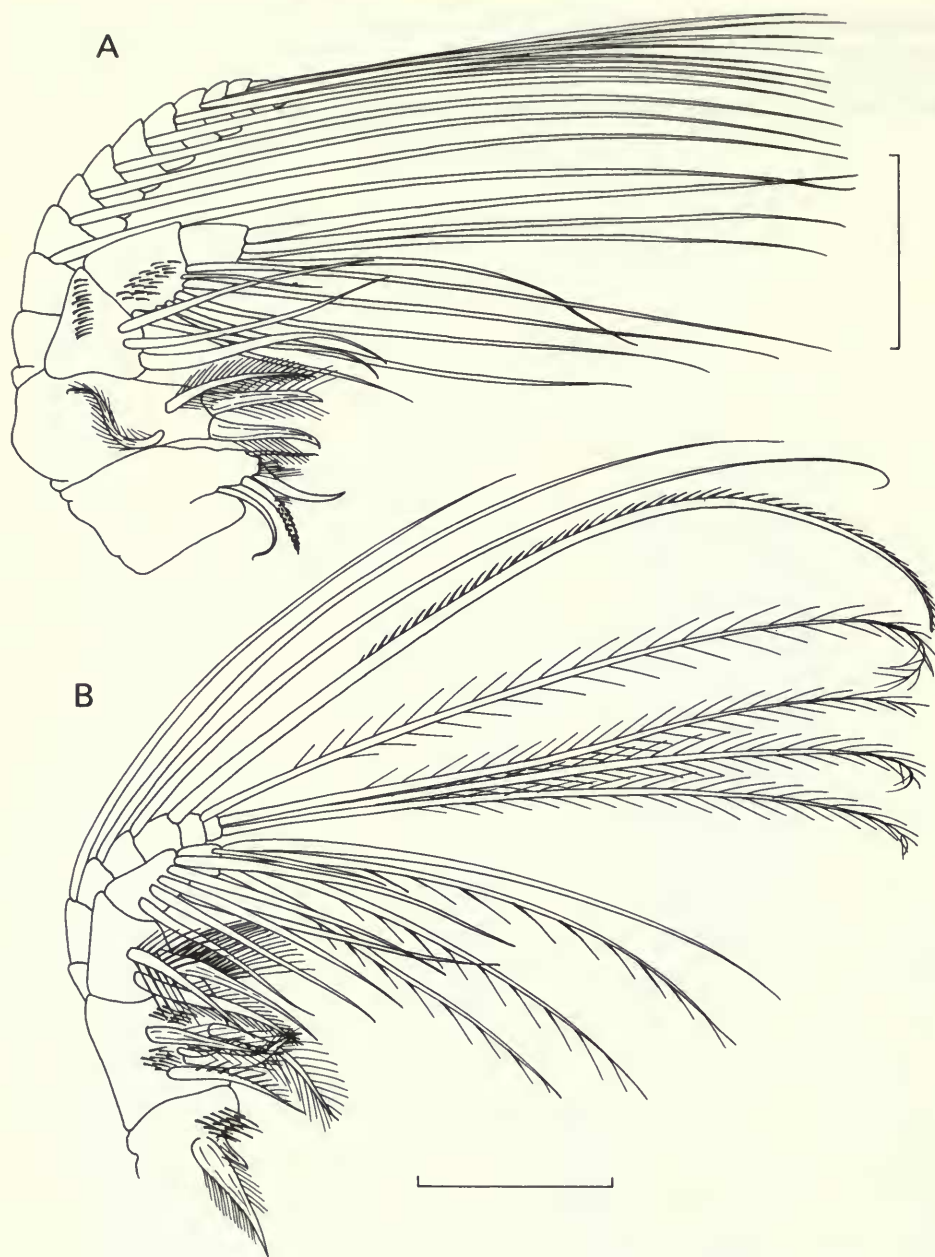


Fig. 4 Red Sea metanauplius type I. A, antenna, medial; B, mandible, medial. All scale bars 100 μm .

medially directed spinules that extend onto body; second segment bearing 2 short medial setae, 3 subapical setae on ventral surface and 3 distal margin setae.

Seven pairs of limb buds visible through body wall, marked externally only by tiny sclerotised lobes at the tip of each bud. Limb buds presumably representing maxillae and first to sixth thoracopods of subsequent stage. Caudal furca comprising paired lobes, each bearing a long inner seta and a shorter outer seta.

MATERIAL EXAMINED. 3 nauplii and 6 metanauplii collected at and around *Valdivia* Stn 177 (cruise 29) in the central Red Sea (21°25'96"N 38°04'22"E) between 0 and 100 m (see Table 1), in a multiple opening-closing net of mesh 0.1 mm. 1 nauplius and 2 metanauplii stored in the collections of the BM(NH), Reg. Nos 1988.100–102.

REMARKS. The metanauplius type I from the Red Sea is very similar to that described from the South China Sea by Grygier (1987a). There are small differences in the armature and segmentation of the antenna, mandible and maxillule, in the size of the caudal processes, and in the relative lengths of the caudal spine and setae on the lobes of the caudal furca. However, the basic organisation of these larvae is the same. As established by Grygier (1987a), their possession of rudiments of 6 pairs of thoracopods implies a maxillopodan affinity. The flattened, bowl-shaped dorsal shield is typical of the Ascothoracida and the possession of an equatorial ring of pores around the shield margin which is found only in some families of Ascothoracida (Grygier, 1987a) is here regarded as a derived character. These Red Sea larvae are referred to the Ascothoracida and, on the basis of similarities in the caudal region, possibly to the family Lauridae. Ascothoracid larvae of this type were distributed irregularly in small numbers in the upper 100 m (see Table 1) in the central Red Sea. None was found further north, above the Kebrit Deep.

The free swimming nauplius does not contain an obvious store of yolk. This, combined with its highly setose antenna and mandible each bearing well developed gnathobases, suggests that it is a planktotrophic feeder. The metanauplius is about 1.6 times longer than the nauplius and shows a marked increase in the numbers of limb segments. It is inferred from this that there is at least one stage, intermediate in size and limb segmentation, between the two stages described above. The metanauplius is clearly equivalent to the sixth nauplius (NVI) of cirripedes. The primordia of the 6 pairs of thoracopods visible through the integument indicate that the next moult will be to the equivalent of the cyprid stage of development. The presence of a well developed, setose maxillulary rudiment tends to confirm that the metanauplius is equivalent to the cirripede NVI which may have a similar maxillulary rudiment (Moyse, 1987).

The earlier nauplius is more difficult to equate precisely with a given nauplius stage of cirripedes. It appears to be a mid-development stage, most likely a NIV because it possesses 2 preaxial setae on the antennule. Whilst antennule segmentation varies within the cirripedes the sequence of appearance of preaxial setae on the antennule is remarkably constant. Typically the number of preaxial setae is 0 in NI–NII, 1 in NIII, 2 in NIV and 3 in NV–NVI. This pattern occurs repeatedly in both lepadomorph cirripedes, such as *Capitulum mitella* Linnaeus (Yasugi, 1937), and balanomorphs, such as *Balanus eburneus* Gould (Costlow & Bookhout, 1957) and *Tetraclita serrata* Darwin (Griffiths, 1979). Also the presence of 4 setae on the apical segment of the endopod of both the antenna and mandible is regarded as typical of the cirripede NIV, although this number does vary within the cirripedes.

Thus, the free-living, postbrooding phase of ontogeny appears to comprise 3 or more stages. The length of any brooded phase, prior to release of the larvae, is unknown but may be relatively short. This presumed ontogenetic pattern is much less modified than that of any other ascothoracid (data from Grygier, 1984). The discovery of the nauplius stage, probably equivalent to the cirripede NIV, confirms Grygier's (1987a) prediction that when ascothoracids release feeding naupliar stages these will resemble late instar cirripede larvae more closely than when nauplii are brooded.

Metanauplius type II

A single metanauplius (Fig. 5) was found which differed significantly from that described above. It is 808 µm in length and has the same basic organisation. The primordia of the maxillae and 6 pairs of thoracopods are visible through the integument but are smaller and more anteriorly located than in the above metanauplius. Other differences include: the limbs are relatively smaller, the antennary exopod is only 8-segmented, the mandibular exopod is only 5-segmented, the nauplius eye is lacking, the labrum is broader and truncate, the maxillules have 5 setae, the caudal processes are very small, the caudal furca bears 2 subequal pairs of setae, and there is no trace of any median caudal spine.

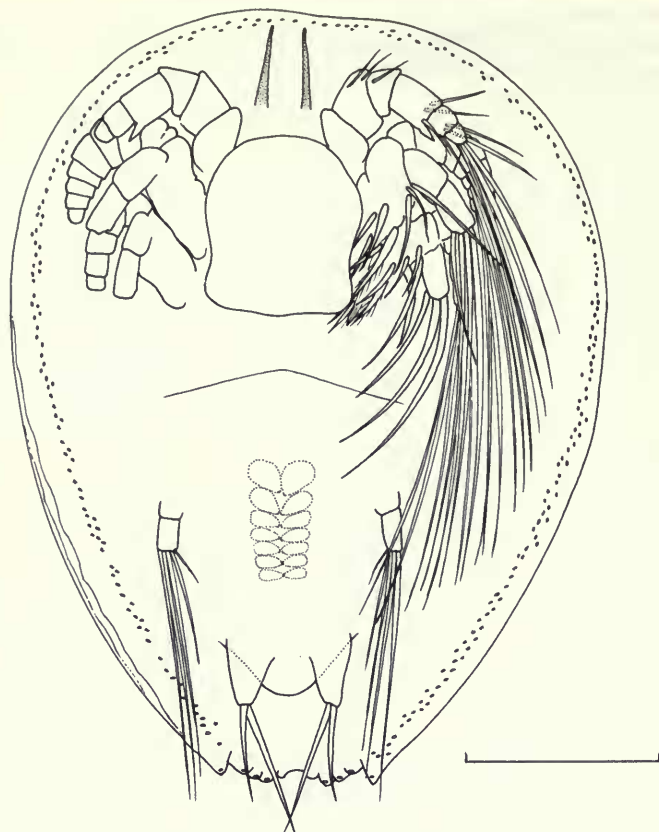


Fig. 5 Red Sea metanauplius type II, ventral view. Scale bar 200 μ m.

MATERIAL. A metanauplius collected on 23 February 1981 in the central Red Sea ($21^{\circ}23.1'N$ $38^{\circ}04.7'E$) during *Valdivia* cruise 29 between 0 and 50 m, in a multiple opening-closing net of mesh 0.1 mm. Stored in the collections of the BM(NH), Reg. No. 1988.198.

REMARKS. This metanauplius is also identified as that of an ascothoracid probably of the family Lauridae, but there are sufficient differences to indicate that it represents a second species from the Red Sea. It differs from the Red Sea metanauplius type I and resembles the metanauplius described by Grygier (1987a) from the South China Sea in the following respects: the segmentation of the antennary and mandibular exopods, the maxillules have 5 setae, the caudal processes are small and the 2 pairs of setae on the caudal furca are subequal in length. It differs from the South China Sea specimen in the lack of a median caudal spine.

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